

Water Quality in the South Bay Region off San Diego, Southern California

Spatial and Temporal Trends in Bacteria Levels

Dave James and Ami Groce
City of San Diego Marine Biology Laboratory (dwjames@sandiego.gov)

INTRODUCTION

The City of San Diego's ocean monitoring program for the South Bay Ocean Outfall (SBOO) has been conducted since 1995 in accordance with NPDES permit requirements for the City's South Bay Water Reclamation Plant (SBWRP) and/or the International Wastewater Treatment Plant (IWTP) operated by the International Boundary and Water Commission. In addition to treated IWTP and SBWRP effluent discharged via the SBOO, the South Bay region receives contaminated water from several major non-point sources, including the Tijuana River, San Diego Bay, and Los Buenos Creek in northern Baja California. Pre-discharge (1995–1998) indicator bacteria densities in water samples from shore and offshore stations were compared to those from post-discharge years (1999–2005). Spatial and temporal trends in total and fecal coliform levels were examined to investigate possible effects of the SBOO discharge and other non-point sources of contamination.

MATERIALS AND METHODS

Water samples for bacteriological analyses were collected at fixed shore and offshore sampling sites from 1995–2005 (**Figure 1**). Weekly sampling was performed at 11 shore stations to monitor bacteria levels along public beaches. Three shore stations (S0, S2, S3) are located south of the US/Mexico border and 8 shore stations (S4–S6, S8–S12) are within the United States between the border and Coronado. In addition, 28 offshore sites are located in a grid surrounding the outfall along the 9, 19, 28, 38, and 55-m depth contours. These 28 offshore stations were sampled monthly, usually over a 3-day period.

Seawater samples from the 11 shore stations were collected from the surf zone in sterile 250-mL bottles. Offshore seawater samples were collected at 3 discrete depths; these samples were collected using either a series of Van Dorn bottles or a rosette sampler fitted with Niskin bottles. The seawater samples were then transported on ice to the City's Marine Microbiology Laboratory for bacterial analyses within 8 hours of sample collection. The Marine Microbiology Laboratory follows guidelines issued by the EPA Water Quality Office, Water Hygiene Division and the California State Department of Health Services (CDHS) Environmental Laboratory Accreditation Program with respect to sampling and analytical procedures (Bordner et al. 1978, Greenberg et al. 1992).

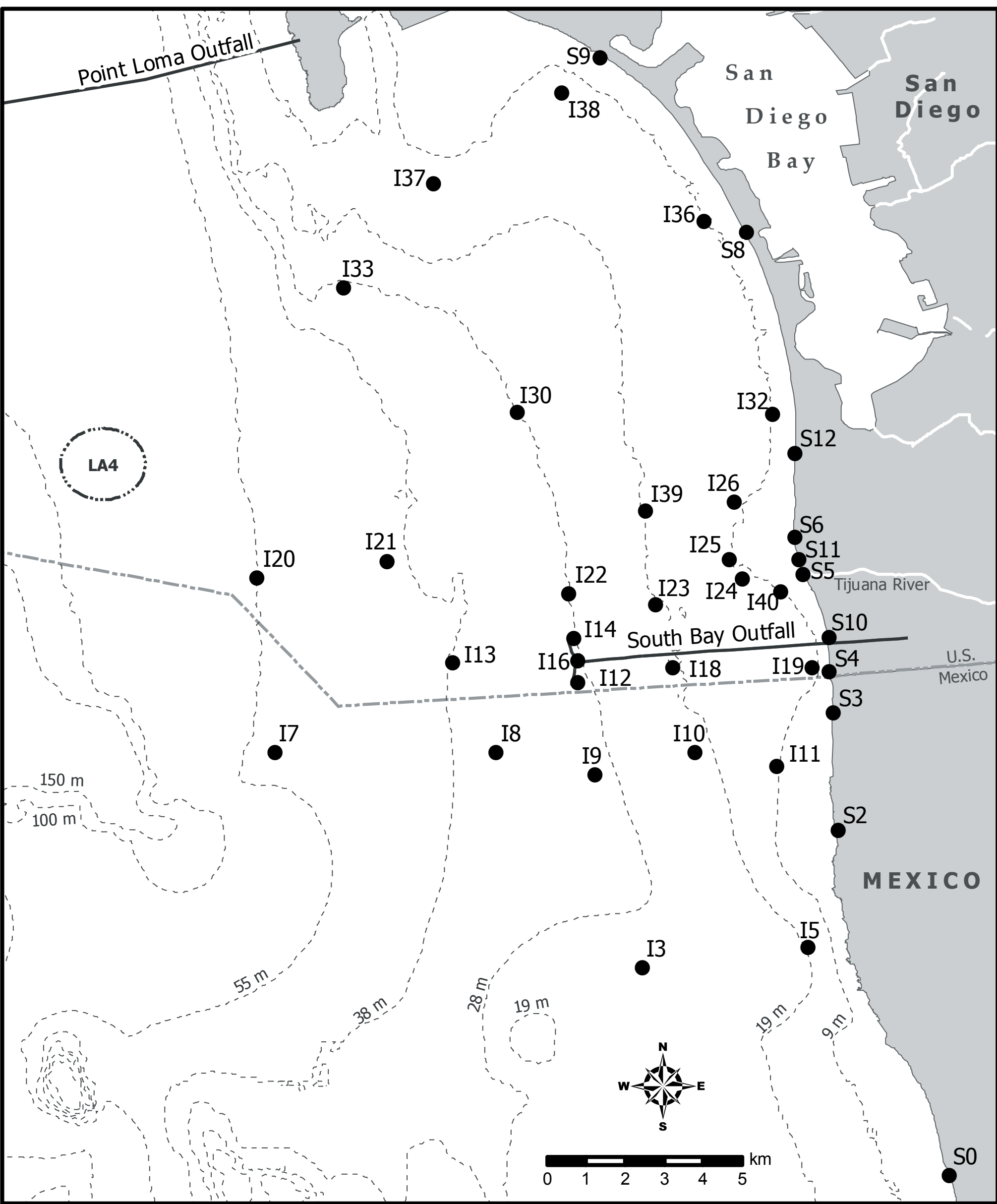


Figure 1
Water quality monitoring stations where bacteriological samples were collected, South Bay Ocean Outfall Monitoring Program.

RESULTS AND CONCLUSIONS

Elevated bacterial densities along the shoreline appeared to be related to sources other than the SBOO. Proximity to the Tijuana River and Los Buenos Creek discharges influenced bacteriological levels along the shoreline before and after the onset of discharge from the SBOO (**Figure 2**). The highest densities of fecal coliform bacteria generally occurred at the shore stations closest to the Tijuana River (S5, S6, S10, S11), where contaminants from upstream sources (e.g., sod farms and runoff not captured by the canyon collector system) and the estuary are released during increased river flow and extreme tidal exchanges (Largier et al. 2004). For example, station S5, located next to the Tijuana River mouth, usually had the highest bacteria levels of all of the shore stations sampled. Station S0, the southernmost shore station, was likely impacted by discharge from the nearby Los Buenos Creek and/or southerly longshore flow carrying Tijuana River discharge (Ocean Imaging 2004). The 2 northern stations along the Coronado shore had the lowest overall bacteriological densities of all shore stations.

River discharge and runoff during and after storm events strongly affected water quality conditions during years with heavy rainfall. Bacterial concentrations from shore stations indicate that waters discharged from the Tijuana River, Los Buenos Creek, and other non-point source stormwater runoff can adversely impact water quality along the shore (**Figure 3**). Annual fecal coliform densities from shore stations increased and decreased

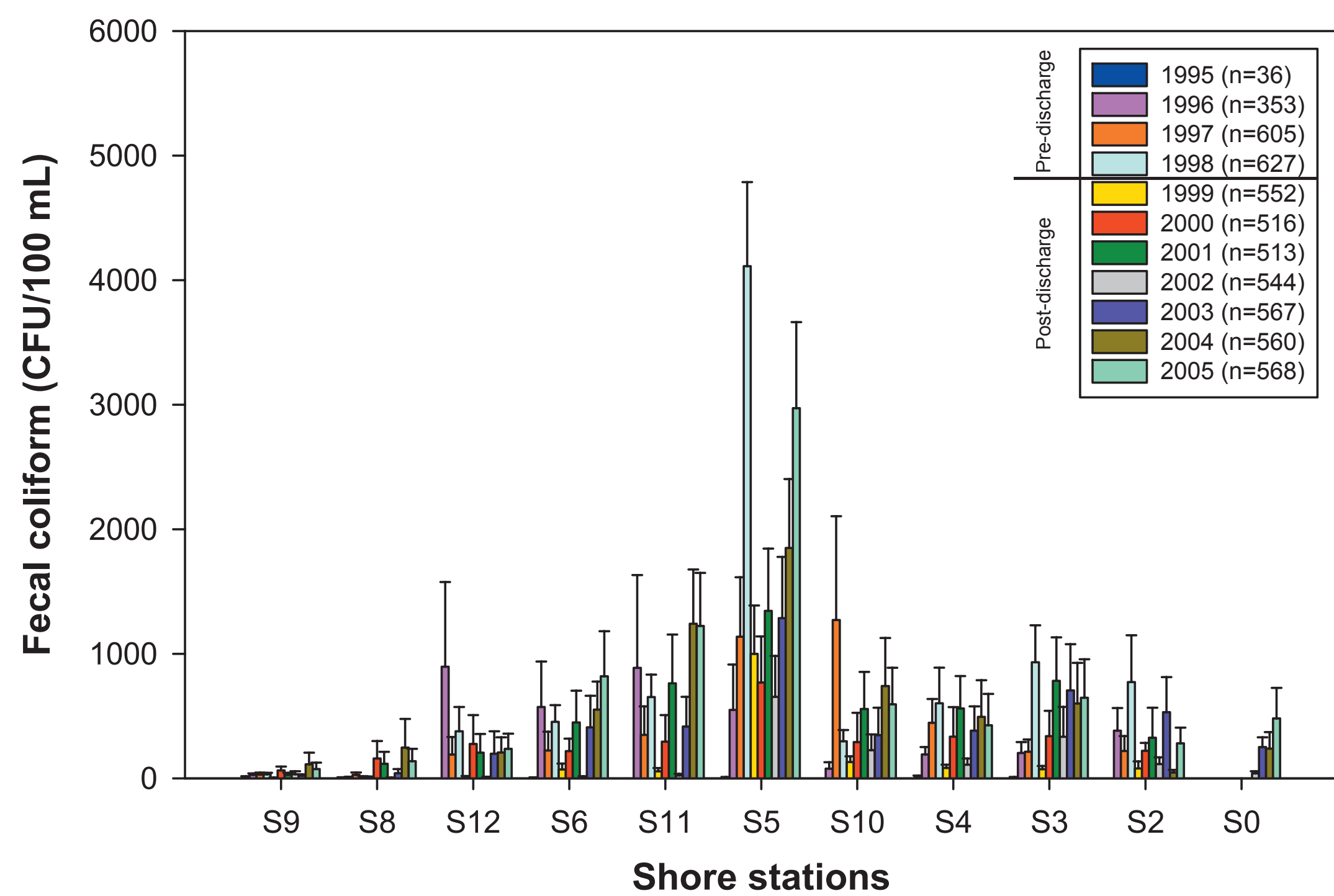


Figure 2
Mean annual fecal coliform densities (mean±SE) for each SBOO shore station from 1995–2005. Stations are arranged from north to south on the x-axis. Stations S5, S6, and S11 are all within 1 km of the Tijuana River. Sampling for stations S10–S12 started in October 1996 and station S0 in August 2002.

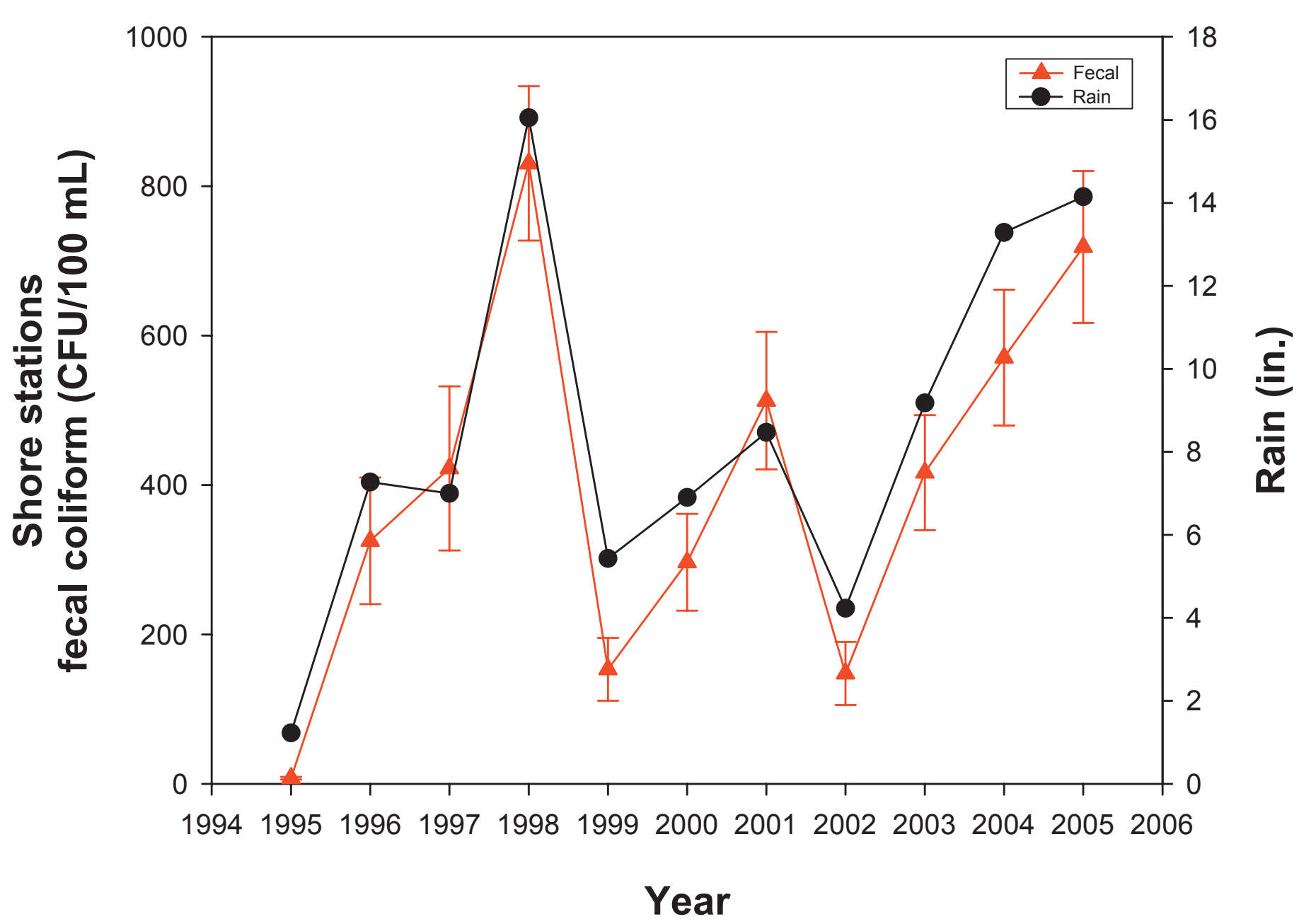


Figure 3
Mean annual fecal coliform densities (mean±SE) from SBOO shore stations (1995–2005). Shoreline sampling began in July 1995. Rainfall data from July–December is used for 1995. Rainfall is measured at Lindbergh Field, San Diego, CA.

with corresponding changes in rainfall. The wide dispersal of the Tijuana River turbidity plume is evident through visible satellite imagery data (**Figure 4**). Offshore station water quality conditions were also impacted by river discharge and storm runoff. The highest fecal coliform densities in surface waters (≤ 2 m) during the pre-discharge period (1995–1998) were collected from nearshore stations (e.g., I5, I23, I25, I40), while

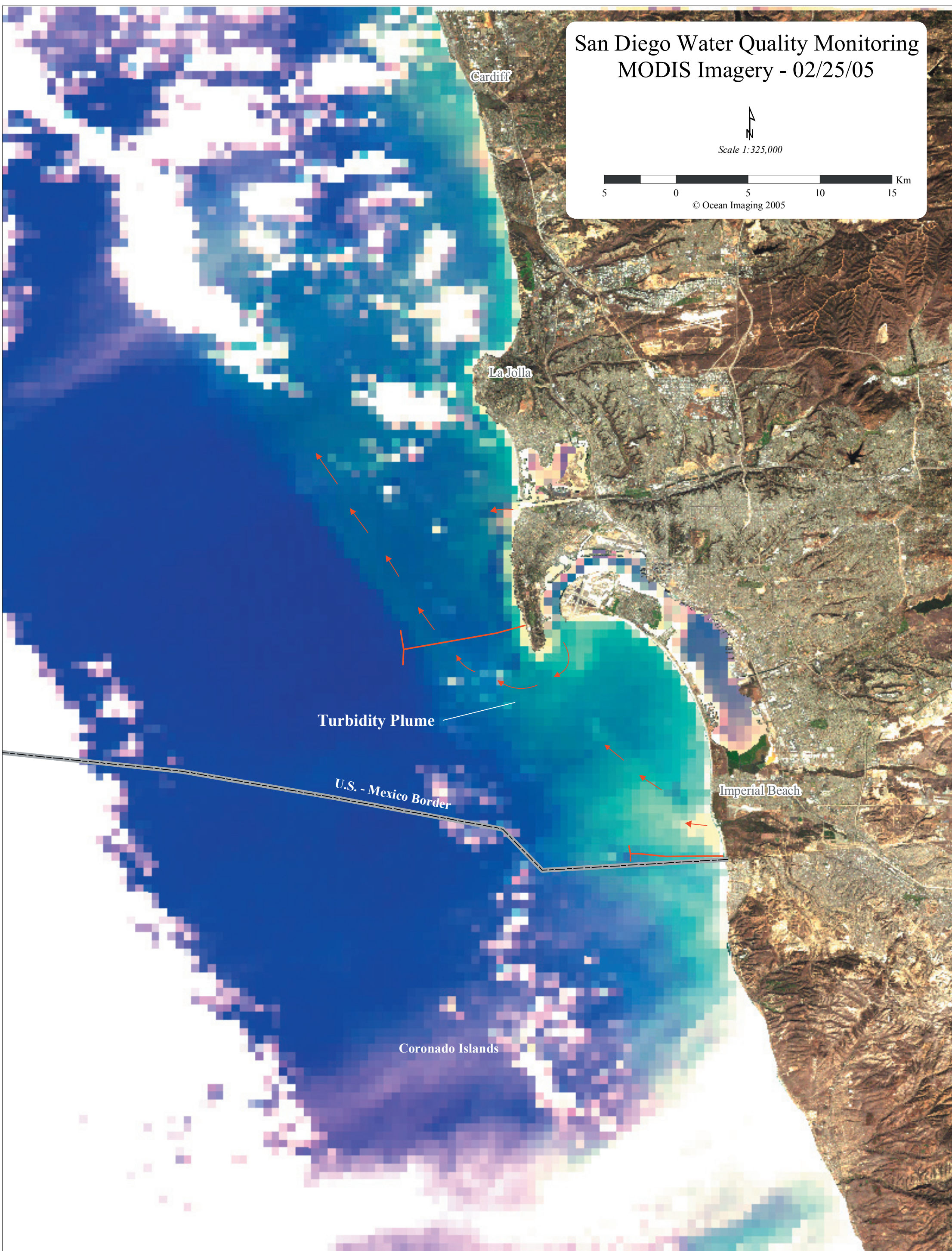


Figure 4
MODIS satellite image showing the San Diego water quality monitoring region on February 25, 2005. Red arrows indicate the direction of the turbidity plume flows. White pixels represent areas obscured by cloud cover.

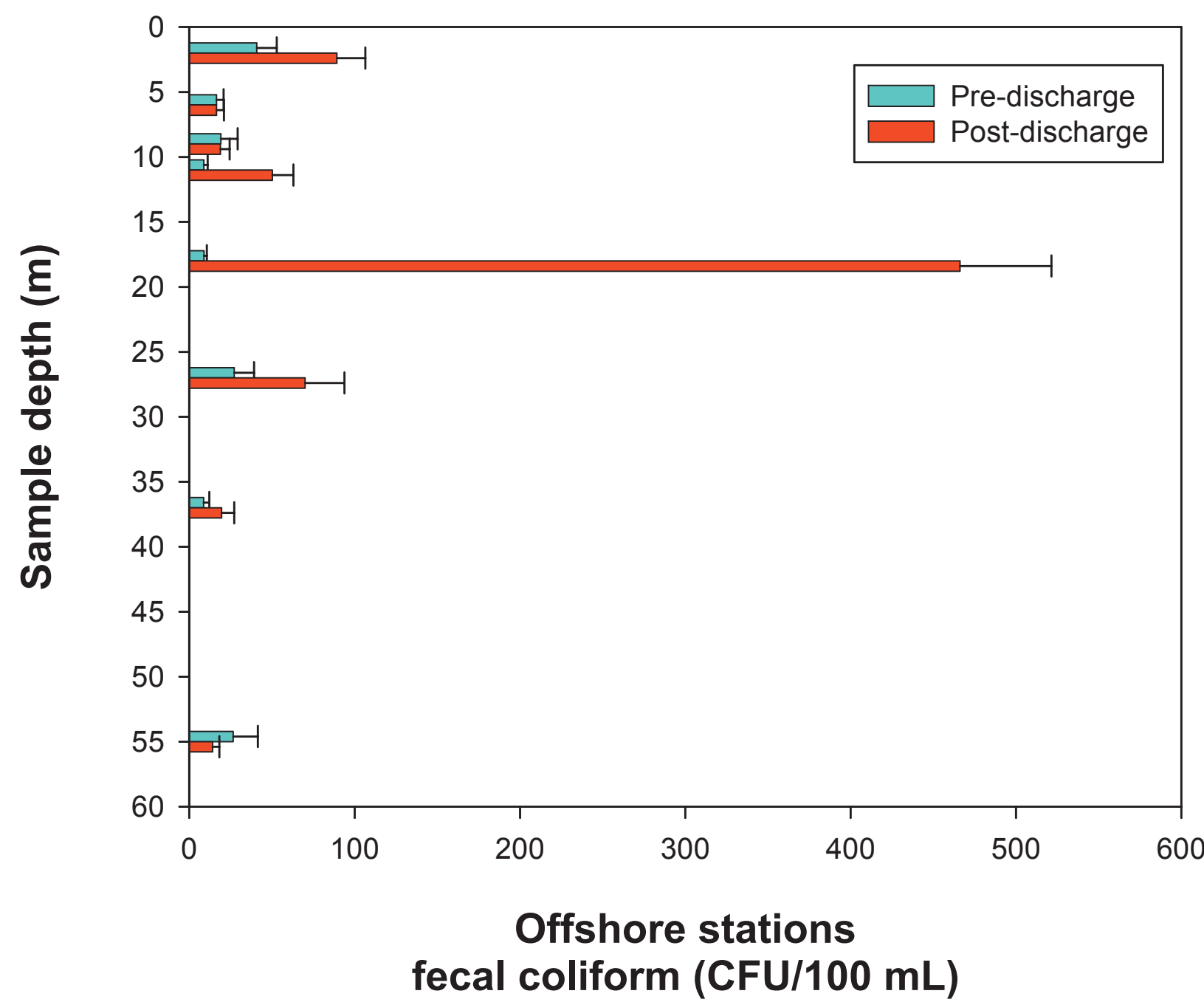


Figure 5
Mean fecal coliform densities (mean±SE) by sample depth from SBOO offshore stations. Samples were taken monthly. Sample sizes ranged from 83 to 2,321 samples per depth. Pre-discharge = 1995–1998 (n = 3384); Post-discharge = 1999–2005 (n = 6791).

those from the post-discharge period (1999–2005) were generally limited to stations near the SBOO diffuser (I12 and I16) and nearshore stations.

The fecal coliform densities indicative of wastewater discharge from the SBOO were generally restricted to offshore areas or at depths below the thermocline (**Figure 5**). The highest densities of fecal coliform bacteria were collected from the 18-m depth samples from stations around the diffusers (stations I12, I14, I18) during the post-discharge period. The number of water samples with contaminated water (samples containing total coliform concentrations ≥ 1000 CFU/mL and a fecal:total (F:T) ratio ≥ 0.1 ; CDHS 2000) that reached surface waters (≤ 2 m depth) increased after the onset of discharge through the SBOO (**Table 1**). The majority of these contaminated surface samples came from stations I12 and I16.

Table 1
Monthly surface (≤ 2 m) water quality samples with high bacteria densities at SBOO offshore stations (1995–2005). Total coliform = CFU/100 mL; F:T = number of samples with total coliform densities ≥ 1000 CFU/100 mL and fecal to total coliform ratio (F:T) ≥ 0.1 (indicative of wastewater).

Year	Samples taken	Number of total coliforms ≥ 1000	Number of samples with F:T ≥ 0.1	Percent of samples with F:T ≥ 0.1
1995	329	1	1	0%
1996	650	10	2	0%
1997	654	49	11	2%
1998	664	37	7	1%
1999	669	43	25	4%
2000	659	61	30	5%
2001	662	45	22	3%
2002	655	45	27	4%
2003	656	52	30	5%
2004	658	45	19	3%
2005	604	76	39	6%

LITERATURE CITED

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